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(54) LOW-NOISE LAMINATED CORE AND WOUND CORE USING HIGH- SILICON STEEL PLATE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a laminated core and a wound core that can sufficiently suppress noises and be manufactured easily at a low cost.
SOLUTION: This laminated core is formed by laminating a plurality of high-silicon steel plates containing 4.5 to 7 wt.% Si, and this laminated wound core is formed by winding them like a coil. The high-silicon steel plate is provided with an adhesion type insulation film which is made mainly of thermoelastic resin on its surface, and the laminated high-silicon steel plates adjoining to each other or the wound and molded high-silicon steel plates adjoining to each other are adhered to each other by means of the adhesive insulation film. The magnetorestriction of a core material is small and an electromagnetic attraction between the steel plates is absorbed by the adhesion type insulation film, thus preventing vibration effectively between the steel plates.

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* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] Si: It is the layer-built iron core of the low noise using the high silicon steel which is the layer-built iron core which consisted of carrying out two or more sheet laminating of the high silicon steel containing 4.5 - 7wt%, and is characterized by the high silicon steel which have the bonded type insulation coat which uses thermoplastics as a principal component on the front face, and a laminating is carried out and adjoin each other having pasted up each high silicon steel by said bonded type insulation coat.
[Claim 2] The layer-built iron core of the low noise using the high silicon steel according to claim 1 characterized by for the board thickness of high silicon steel being 0.5mm or less, and the thickness of the bonded type insulation coat between the high silicon steel which a laminating is carried out and adjoins each other being 0.3-10 micrometers.
[Claim 3] Si: It is the wound core of the low noise using the high silicon steel which is the wound core which consisted of carrying out volume shaping of the high silicon steel containing 4.5 - 7wt% at a coiled form, and is characterized by the high silicon steel sections which have the bonded type insulation coat which uses thermoplastics as a principal component on the front face, and volume shaping is carried out and adjoin each other having pasted up high silicon steel by said bonded type insulation coat.
[Claim 4] The wound core of the low noise using the high silicon steel according to claim 3 characterized by for the board thickness of high silicon steel being 0.5mm or less, and the thickness of the bonded type insulation coat between the high silicon steel sections which volume shaping is carried out and adjoin each other being 0.3-10 micrometers.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the layer-built iron core and wound core which are used for York used in case the iron core of rotating machines, such as a transformer of an electrical machinery and apparatus, an iron core of a reactor, a motor, and a generator, and an alternating current magnetic field are generated.
[0002]
[Description of the Prior Art] The needs of the reduction in the noise of an electrical machinery and apparatus are increasing further by the miniaturization of a power unit in recent years, and RF-ization accompanying efficient-izing, and have been the technical problems that reduction-izing of the noise generated from the iron core of a transformer, a reactor or a motor, etc., etc. also in it is big. although silicon steel is conventionally used for these iron core ingredients widely — the inside of it — silicon — about 6.5wt% — the high silicon steel to contain — soft magnetic characteristics — excelling — magnetostriction — about 0 — and since it is low iron loss, it is observed as an iron core ingredient for low noise recently. however — actual — the cause of generating of the noise — not only magnetostriction vibration of an iron core ingredient — rather — the electromagnetism between iron core ingredients — specific gravity with the big vibration by the suction force — occupying — **** — therefore, such electromagnetism — low noise-ization can be attained only after the oscillating cure by the suction force is made.
[0003] the electromagnetism between iron core ingredients — the approach of binding an iron core tight in a bolt or a band is learned as a cure for controlling vibration by the suction force, and, otherwise, the following proposals are made.
** In JP,3-135007,A or JP,4-61211,A, using the small ingredient of magnetostriction for a part of iron core is proposed.
** In JP,5-291053,A, the iron core which has arranged the grain-oriented magnetic steel sheet to the core, and has arranged a low magnetostriction ingredient like silicon steel 6.5% on the both sides is proposed.
** In JP,5-251244,A, the low noise iron core which has arranged the low magnetostriction ingredient in the center section, among those has arranged a magnetic material for RFs like a ferrite on the periphery, and took RF iron loss into consideration is proposed.
[0004] However, in the iron core by these proposals, although a certain extent is stopped in generating of the noise, the effectiveness is not enough, and in order to fully suppress the noise, there is wrap need about a transformer or a reactor with acoustic material or a noise insulation box. Moreover, the actual manufacture itself is difficult for the iron core proposed by JP,5-251244,A. On the other hand, in JP,4-361508,A, while setting surface roughness of the insulating coat of a steel plate to 3.5 micrometers or more by Rmax, using high silicon steel as an iron core ingredient, the iron core which suppressed the oscillating noise generated between plates is proposed by inserting the impregnant (resin system adhesives) which served as the adhesion function between steel plates.
[0005]
[Problem(s) to be Solved by the Invention] However, it is very difficult like this JP,4-361508,A to infiltrate resin system adhesives in fact between [whole] steel plates, and it difficult to attain the low noise as shown in this official report for this reason. That is, although it is said that the noise becomes small, so that the surface roughness of an insulating coat is large in this official report and the 12.5-micrometer thing is shown for surface roughness by Rmax in the example, even if surface roughness performs vacuum impregnation by about 10-20 micrometers by Rmax in fact for about several hours, resin system adhesives sink in only from the edge of a layer-built iron core to about 10mm. Therefore, even if actual manufacture of an iron core as shown in this official report is very difficult and it is able to manufacture, great time and effort and cost will be required.
[0006] In view of such a conventional problem, this invention demonstrates the property of high silicon steel which is a low magnetostriction ingredient to the maximum extent, and the noise is fully suppressed and, moreover, it sets offer of easy, the layer-built iron core which can manufacture to low cost, and a wound core as the purpose.
[0007]
[Means for Solving the Problem] In order to solve such a technical problem, the configuration by which it is characterized [of this invention] is as follows.
(1) It is the layer-built iron core of the low noise using the high silicon steel which is the layer-built iron core which consisted of carrying out two or more sheet laminating of the high silicon steel containing Si:4.5 - 7wt%, and is characterized by the high silicon steel which have the bonded type insulation coat which uses thermoplastics as a

principal component on the front face, and a laminating is carried out and adjoin each other having pasted up each high silicon steel by said bonded type insulation coat.
(2) The layer-built iron core of the low noise using the high silicon steel characterized by for the board thickness of high silicon steel being 0.5mm or less, and the thickness of the bonded type insulation coat between the high silicon steel which a laminating is carried out and adjoins each other being 0.3-10 micrometers in the layer-built iron core of the above (1).
(3) It is the wound core of the low noise using the high silicon steel which is the wound core which consisted of carrying out volume shaping of the high silicon steel containing Si:4.5 - 7wt% at a coiled form, and is characterized by the high silicon steel sections which have the bonded type insulation coat which uses thermoplastics as a principal component on the front face, and volume shaping is carried out and adjoin each other having pasted up high silicon steel by said bonded type insulation coat.
(4) The wound core of the low noise using the high silicon steel characterized by for the board thickness of high silicon steel being 0.5mm or less, and the thickness of the bonded type insulation coat between the high silicon steel sections which volume shaping is carried out and adjoin each other being 0.3-10 micrometers in the wound core of the above (3).
[0008]
[Embodiment of the Invention] Although the layer-built iron core and wound core of this invention use the high silicon steel containing Si:4.5-7% as an iron core ingredient, the iron core consists of that a laminating or the high silicon steel which volume shaping is carried out and adjoin each other paste [the high silicon steel which this iron core ingredient slack quantity silicon steel has the bonded type insulation coat on the front face, and has such a bonded type insulation coat] up by the bonded type insulation coat. therefore — while such a layer-built iron core and a wound core are very easy to manufacture — the magnetostriction of an iron core ingredient — small — and the electromagnetism between steel plates — in order that a bonded type insulation coat may absorb a suction force, vibration between steel plates is suppressed effectively, and the noise is very small.
[0009] The detail of this invention is explained below. In this invention, Si:4.5 - 7wt% high silicon steel is used as an iron core ingredient. Si cannot obtain low magnetostriction sufficient in less than 4.5 wts. Although magnetostriction will increase again if Si content serves as min near 6.6wt% and Si increases further, it is a value low still enough. However, since a steel plate will become very weak if Si content exceeds 7wt(s)%, manufacture of sheet metal becomes impossible.
[0010] Moreover, C:100 ppm or less, Mn:50ppm - 0.5wt% can be made to contain as such high silicon steel. Although it is effective that there is an operation which prevents embrittlement by S and 50 ppm or more add for this reason when manufacturing the small high silicon steel of magnetostriction, Mn is not desirable in order to promote embrittlement of steel, if that addition exceeds 0.5wt(s)%. Moreover, if the addition of C exceeds 100 ppm, while workability will deteriorate, it is not desirable in order to cause increase of iron loss.
[0011] In this invention, the high silicon steel which constitutes an iron core has a bonded type insulation coat on a front face, and the steel plates which a layer-built iron core or a wound core adjoins have the configuration pasted up by the above-mentioned bonded type insulation coat. Si — 6.5wt(s)% — it was made from the high silicon steel of 0.3mm of board thickness to contain, the 30-sheet laminating of what pierced and processed the steel plate into EI mold (EI-54) was carried out, EI mold layer-built iron core of example of the following manufacture (1) - (4) was produced by the approach of assembling this layered product to an iron core, and those measurement of sound level was performed.
[0012] The example of manufacture (1) : The bonded type insulation coat which consists of thermoplastics on the surface of a steel plate is given. The example of layer-built iron core manufacture on which between laminating steel plates was pasted up by heat-treating at 240 degrees C, carrying out the laminating of what pierced and processed this steel plate, and pressurizing in the direction of a steel plate laminating with the welding pressure of 10kg/cm2 (2) : A well-known inorganic organic system insulation coat is given on the surface of a steel plate. The laminating of what pierced and processed this steel plate is carried out. it is the layer-built iron core which infiltrated the resin system adhesives (epoxy resin) which served as the adhesion function into the iron core of the example of the example of layer-built iron core manufacture (4):above-mentioned manufacture (2) which infiltrated H sorts of insulating varnishes into the iron core of the example of the example of layer-built iron core manufacture (3):above-mentioned manufacture (2) which welded a total of six places of an end face in the direction of a steel plate laminating — Surface roughness Rmax of the steel plate of the back with inorganic organic system insulation ****** of the layer-built iron core of the above-mentioned example of manufacture (4) is 12 micrometers, and sinking-in processing of resin system adhesives was performed in the vacuum for 3 hours.
[0013] Measurement of the noise (A scale) of these layer-built iron cores was performed in the location which is distant from the transverse plane of an iron core 10cm in the condition of having excited on condition that 1kHz and B=1T. The result is shown in Table 1. The laminating of the steel plate which the noise decreases by no less than 15dB compared with the layer-built iron core which carried out the laminating of the high silicon steel which has an inorganic organic system insulation coat well-known in the layer-built iron core of the example of this invention to which the laminating of the steel plate which has a bonded type insulation coat was carried out according to this table, and has a well-known inorganic organic system insulation coat is carried out, and even if compared with the layer-built iron core which infiltrated an insulating varnish and resin system adhesives behind the laminating, the noise is decreasing by 4-7dB.
[0014] Moreover, after the above-mentioned trial, as a result of decomposing and investigating the example of

manufacture (3), and the layer-built iron core of (4), it became clear that neither an insulating varnish nor resin system adhesives had fully permeated to an iron core center section in these iron cores. It turned out that it is very difficult for resin system adhesives not to fully permeate to an iron core center section, therefore to make an impregnant permeate completely to an iron core center section by this method especially in spite of having performed sinking-in processing in the vacuum in the iron core of the example of manufacture (4) for 3 hours. And it is considered to be the cause which is inferior in the noise-reduction effectiveness of the above-mentioned example of manufacture (3), and the iron core of (4) that sinking in is inadequate in this way.

[0015] Next, in order to check the effectiveness by the bonded type insulation coat of the iron core of this invention, EI mold layer-built iron core was manufactured by the completely same approach as above-mentioned example of manufacture (1) - (4) by having been made from 3%Si nondirectional silicon steel with large magnetostriction, and the same measurement-of-sound-level trial was performed. Table 2 shows the result and the manufacture conditions of example of manufacture (1) - (4) of it are completely the same as that of example [of Table 1] of manufacture (1) - (4) only by material steel plates differing. According to this, when the large iron core ingredient of magnetostriction like silicon steel is used 3%, a bonded type insulation coat is given to a steel plate front face, and it turns out that the noise-reduction effectiveness by carrying out the laminating of this is very small. This is considered to be because for the oscillating noise generated from the steel plate itself by magnetostriction to be loud more than the viscoelasticity force of a bonded type insulation coat absorbs oscillating friction between plates. Therefore, it is very important when using the small iron core ingredient of magnetostriction attains the low noise.

[0016] Furthermore, in order to check the difference in the operation effectiveness with the iron core of JP,4-361508,A described previously, the relation between surface roughness Rmax of the bonded type insulation coat of high silicon steel and the noise (A scale) of an iron core was investigated. the layer-built iron core used for this trial -- Si -- 6.5wt(s)% -- the laminating steel plate was pasted up by heat-treating at 240 degrees C, giving the bonded type insulation coat which becomes the front face of high silicon steel of 0.3mm of board thickness to contain from thermoplastics by the thickness of 5 micrometers, carrying out the 70-sheet laminating of what pierced and processed this steel plate into EI mold (EI-54), and pressurizing this layered product with the welding pressure of 10kg/cm2 in the direction of a steel plate laminating.

[0017] Measurement of the noise (A scale) of a layer-built iron core was performed in the location which is distant from the transverse plane of an iron core 10cm in the condition of having excited on condition that 1kHz and B=1T. Drawing 1 does not show the result and correlation is not looked at at all by surface roughness Rmax of the bonded type insulation coat in front of a laminating, and the noise of an iron core. In the laminating iron core and volume iron core of this invention, a thermoplastic bonded type insulation coat fills effectively with the pressurization heat-treatment at the time of iron core shaping the opening between the steel plates produced with the irregularity on the front face of a steel plate, and between layers is firmly fixed by this with them. Therefore, the surface roughness of the bonded type insulation coat in front of a laminating is not related to the operation effectiveness of invention at all.

[0018] Next, the relation between the thickness of the bonded type insulation coat between the steel plates after being fabricated by the iron core, and the noise of an iron core was investigated using the same layer-built iron core as the trial of drawing 1 . this trial -- Si -- 6.5wt(s)% -- the bonded type insulation coat which becomes the front face of the high silicon steel (surface roughness Rmax of a steel plate base is 7 micrometers) of 0.3mm of board thickness to contain from thermoplastics was given by various thickness, the iron core was produced at the same process as the trial of drawing 1 by having been made from these steel plates, and it used for measurement of sound level. Moreover, measurement of sound level was performed on the same conditions as the trial of drawing 1 .

[0019] Drawing 2 shows the result, and if the thickness of the bonded type insulation coat between the steel plates fabricated to the iron core is 0.3 micrometers or more, sufficient noise-reduction effectiveness is acquired. However, since problems, such as condensation exfoliation of a coat and ****, are produced while lowering the space factor of an iron core, if thickness becomes large too much, as for thickness, it is desirable to be referred to as 10 micrometers or less. In addition, although the effect to the noise of the board thickness of a steel plate was also investigated, it turned out that the effectiveness of an abbreviation EQC is acquired for board thickness in 0.5mm or less.

[0020] Moreover, in consideration of possibility of affecting noise generating of an iron core, the relation between the thickness (thickness after fabricating to an iron core) of the surface roughness of a steel plate base and a bonded type insulation coat, and noise generating of an iron core was investigated under the surface roughness of a steel plate base influencing the property of a bonded type insulation coat. In this trial, the bonded type insulation coat which becomes the front face of the high silicon steel (Si content: 6.5wt%, 0.3mm of board thickness) which has various surface roughness Rmax(es) from thermoplastics was given by various thickness, the iron core was created at the same process as the trial of drawing 1 by having been made from these steel plates, and it used for measurement of sound level. Moreover, measurement of sound level was performed on the same conditions as the trial of drawing 1 .

[0021] Drawing 3 does not show the result and it turns out that surface roughness Rmax of a steel plate does not have not much big effect on noise generating. That is, it turns out that it adheres to the surface roughness of a steel plate substantially, and the noise-reduction effectiveness by the bonded type insulation coat is acquired [that there is nothing] that what is necessary is to acquire sufficient noise-reduction effectiveness even if a bonded type

insulation coat is thin when the surface roughness of a steel plate is comparatively small, and just to enlarge thickness of a coat according to the granularity when the surface roughness of a steel plate is comparatively large therefore.

[0022] A bonded type insulation coat is a coat which uses as a principal component the thermoplastics which has bond strength predetermined at about 140 degrees C, and has required insulation resistance in consideration of generation of heat at the time of considering as an iron core. When one sort of urethane resin, an alkyd resin, phenol resin, an epoxy resin, melanin resin, polyurethane resin, acrylic resin, vinyl acetate resin, silicone, and polyimide resin or two sorts or more can be used and thermal resistance is required as this thermoplastics, for example, non-subtlety particles, such as an oxide particle, may be added in the above-mentioned resin. This invention pierces the target iron core, it is a layer-built iron core, and the cut core and a wound core like toroidal one which piled up the steel plate cut down by processing of an electron discharge method, laser beam machining, etching, etc., and the magnitude of an iron core is not asked.

[0023] In order to manufacture the layer-built iron core of this invention, it gives the front face containing Si:4.5 - 7wt% of high silicon steel by applying and drying the bonded type insulation coat which uses thermoplastics as a principal component, and two or more sheet laminating of what cut down this high silicon steel in the predetermined configuration is carried out. And the high silicon steel which a laminating is carried out and adjoin each other by heat-treating to the temperature which the thermoplastics of a bonded type insulation coat softens is pasted up by the bonded type insulation coat, pressurizing the layered product in the direction of a steel plate laminating.

[0024] Moreover, in order to manufacture a wound core, volume shaping of the high silicon steel which gave the bonded type insulation coat as mentioned above is carried out at a coiled form, and this Plastic solid is heat-treated. Since a certain amount of welding pressure is added in the direction of a laminating of a steel plate with the tension at the time of carrying out volume shaping of the steel plate at a coiled form, in the case of a wound core, grant of the welding pressure from the outside at the time of being heat-treatment may be unnecessary, therefore grant of the welding pressure in the direction of a steel plate laminating is carried out to it if needed.

[0025] Moreover, after fabricating an iron core, distorted picking annealing can be performed for the purpose of configuration immobilization and a magnetic-properties improvement of a wound core, magnetic properties are improved by this distorted picking annealing, and the noise-reduction effectiveness also improves a little in connection with this. As for this distorted picking annealing, it is desirable to carry out at 700-850 degrees C, and when performing distorted picking annealing, it is desirable to use thermoplastics with thermal resistance for a bonded type insulation coat. In addition, although a bonded type insulation coat deteriorates a little by distorted picking annealing, since it is fixed between layers, the noise-reduction effectiveness is seldom spoiled. Moreover, in order that magnetic flux may cross between the layers of a steel plate also about the iron core which between [whole] layers is certainly fixed by the bonded type insulation coat, and the layer-built iron core and volume iron core of this invention do not have the fault that the interior a varnish or whose adhesives are iron cores like the method into which an insulating varnish and resin system adhesives are infiltrated does not spread, and has magnetic gaps, such as an EI type core and a cut core, for this reason, that effectiveness is fully large.

[0026]

[Table 1]

表 1

区　分	騒音(dBA)
製造例(1)	31
製造例(2)	46
製造例(3)	38
製造例(4)	35

[0027]

[Table 2]

表 2

区　分	騒音(dBA)
製造例(1)	62
製造例(2)	68
製造例(3)	64
製造例(4)	63

[0028]

[Example] [Example 1] Si content produced EI layer-built iron core of example of the following manufacture (1) - (3)

5.9wt% 3.0wt(s)% by being made from the silicon steel (0.3mm of board thickness) which is 6.5wt%, respectively.
The example of manufacture (1) : Pierce each above-mentioned steel plate which applied the bonded type insulation coat which consists of thermoplastics (acrylic resin), and was dried in a predetermined configuration (EI-65), and the laminating of this is carried out. Between laminating steel plates is pasted up by the bonded type insulation coat by carrying out pressurization heat-treatment with 200 degrees C and the welding pressure of 15kg/cm2 whenever [stoving temperature]. The example of layer-built iron core manufacture fabricated to the iron core (2) : A well-known inorganic organic system insulation coat is applied. The example of layer-built iron core manufacture which pierced in the predetermined configuration (EI-65), carried out the laminating of this, and bolting [example / the steel plate] and fabricated each dried above-mentioned steel plate (3) : A well-known inorganic organic system insulation coat is applied. The layer-built iron core into which resin system adhesives were infiltrated in the vacuum after piercing in a predetermined configuration (EI-65), carrying out the laminating of this and bolting [the steel plate] and fabricating each dried above-mentioned steel plate (sinking-in time amount: 3 hours) [0029] Thus, the acquired layer-built iron core was excited on condition that 1kHz and B=1T, and the noise was measured on A scale in the location which is distant from an iron core 10cm with a noise meter. The result is shown in Table 3. According to this, the high silicon steel (Si:6.5wt% and 5.9wt%) which has a bonded type insulation coat in the layer-built iron core of the example of this invention which carried out the laminating After carrying out the laminating of the high silicon steel which the noise decreases by no less than 15-16dB compared with the layer-built iron core which carried out the laminating of the high silicon steel which has a well-known inorganic organic system insulation coat, and has a well-known inorganic organic system insulation coat, even if compared with the layer-built iron core into which resin system adhesives were infiltrated, the noise is decreasing by no less than 4-5dB. On the other hand, the whole noise level of the effectiveness by carrying out the laminating of the steel plate which has a bonded type insulation coat like this invention highly is [each layer-built iron core using 3% silicon steel] also small.
[0030] [Example 2] Si content produced the cut core (CS200) of example of the following manufacture (1) - (4) 5.7wt% 3.5wt(s)% by being made from the silicon steel (0.1mm of board thickness) which is 6.6wt%, respectively.
The example of manufacture (1) : Volume shaping of ** and each dried above-mentioned steel plate is carried out for the bonded type insulation coat which consists of inorganic system adhesives. The example of cut core manufacture which pasted up between laminating steel plates by the bonded type insulation coat by heat-treating this at 350 degrees C (2) : A well-known inorganic organic system insulation coat is applied. After carrying out volume shaping of each dried above-mentioned steel plate and giving this 800 degrees C and distorted picking annealing of 2 hours, The example of cut core manufacture into which the insulating varnish was infiltrated (3) : A well-known inorganic organic system insulation coat is applied. After carrying out volume shaping of each dried above-mentioned steel plate and giving this 800 degrees C and distorted picking annealing of 2 hours, The bonded type insulation coat which consists of inorganic system adhesives The example of cut core manufacture into which resin system adhesives were infiltrated in the vacuum (sinking-in time amount: 3 hours) (4) : With **, The cut core which carried out volume shaping of each dried above-mentioned steel plate, pasted up between laminating steel plates by the bonded type insulation coat by heat-treating this at 250 degrees C, and gave this distorted picking annealing at 800 degrees C [0031] Thus, the acquired wound core (cut core) was excited on condition that 2kHz and B=0.5T, and the noise was measured on A scale in the location which is distant from an iron core 10cm with a noise meter. The result is shown in Table 4. According to this, the high silicon steel (Si:6.6wt% and 5.7wt%) which has a bonded type insulation coat in the wound core of the example of this invention which carried out volume shaping After carrying out the laminating of the high silicon steel which has a well-known inorganic organic system insulation coat, even if compared with the wound core into which the noise decreased by about 5-6dB compared with the wound core into which the insulating varnish was infiltrated, and resin system adhesives were similarly infiltrated, the noise is decreasing by about 3dB. On the other hand, the effectiveness by the whole noise level carrying out volume shaping of the steel plate which has a bonded type insulation coat like this invention highly of each wound core using 3.5% silicon steel is also small.
[0032] [Example 3] Si content produced the stator of example of the following manufacture (1) - (3) 5.0wt% 0.5wt (s)% by being made from the silicon steel (0.3mm of board thickness) which is 6.5wt%, respectively.
The example of manufacture (1) : Pierce each above-mentioned steel plate which applied the bonded type insulation coat which consists of thermoplastics (acrylic resin), and was dried in a predetermined configuration, and the laminating of this is carried out. The example of stator manufacture which pasted up between laminating steel plates by the bonded type insulation coat whenever [stoving temperature] by carrying out heating pressure treatment with 280 degrees C and the welding pressure of 20kg/cm2 (2) : A well-known inorganic organic system insulation coat is applied. The example of stator manufacture which pierced each dried above-mentioned steel plate in the predetermined configuration, carried out the laminating of this, and carried out caulking shaping (3) : A well-known inorganic organic system insulation coat is applied. The stator into which each dried above-mentioned steel plate is pierced in a predetermined configuration, the laminating of this is carried out, and resin system adhesives were infiltrated in the vacuum after carrying out caulking shaping (sinking-in time amount: 3 hours) [0033] Thus, the high-speed induction motor produced using the acquired layer-built iron core (stator) was rotated by no-load and 30000rpm, and measurement of sound level was carried out on A scale with the noise meter in the place distant from the motor 10cm. The result is shown in Table 5. According to this, the high silicon steel (Si:6.5wt% and 5.0wt%) which has a bonded type insulation coat in the layer-built iron core of the example of this invention which carried out the laminating After carrying out the laminating of the high silicon steel which the noise decreases by no less than 12-13dB compared with the layer-built iron core which carried out the laminating of the high silicon steel which

has a well-known inorganic organic system insulation coat, and has a well-known inorganic organic system insulation coat, even if compared with the layer-built iron core into which resin system adhesives were infiltrated, the noise is decreasing by 2-3dB. On the other hand, the whole noise level of the effectiveness by carrying out the laminating of the steel plate which has a bonded type insulation coat like this invention highly is [each layer-built iron core using 0.5% silicon steel] also small.

[0034]

[Table 3]

表 3

区　分	騒　音 (dBA)		
	6.5wt%	5.9wt%	3.0wt%
製造例(1)	32	41	64
製造例(2)	48	56	71
製造例(3)	36	46	66

(注) 下線部が本発明例

[0035]

[Table 4]

表 4

区　分	騒　音 (dBA)		
	6.6wt%	5.7wt%	3.5wt%
製造例(1)	40	50	67
製造例(2)	45	56	70
製造例(3)	43	53	68
製造例(4)	41	51	68

(注) 下線部が本発明例

[0036]

[Table 5]

表 5

区　分	騒　音 (dBA)		
	6.5wt%	5.0wt%	0.5wt%
製造例(1)	49	55	69
製造例(2)	61	68	77
製造例(3)	52	57	70

(注) 下線部が本発明例

[0037]

[Effect of the Invention] while manufacture is very easy according to the layer-built iron core and wound core of this invention which were described above — the magnetostriction of an iron core ingredient -- small -- and the electromagnetism between steel plates -- since a bonded type insulation coat absorbs a suction force, vibration between steel plates is suppressed effectively and can reduction-ize the noise more compared with a conventional layer-built iron core and a conventional wound core.

[Translation done.]

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(54)【発明の名称】　高珪素鋼板を用いた低騒音の積層鉄心および巻鉄心

(57)【要約】
【課題】　騒音が十分に抑えられ、しかも簡単且つ低コストに製造できる積層鉄心及び巻鉄心を提供すること
【解決手段】　Ｓｉ：４．５～７ｗｔ％を含有する高珪素鋼板を、複数枚積層することで構成された積層鉄心またはコイル状に巻成形することで構成された巻鉄心であって、高珪素鋼板はその表面に熱可塑性樹脂を主成分とする接着型絶縁皮膜を有し、積層されて隣り合う高珪素鋼板どうしまたは巻成形されて隣り合う高珪素鋼板部どうしが前記接着型絶縁皮膜により接着されており、鉄心材料の磁歪が小さく且つ鋼板間の電磁吸引力を接着型絶縁皮膜が吸収するため鋼板間の振動が効果的に抑えられる。

【特許請求の範囲】
【請求項１】　Ｓｉ：４．５～７ｗｔ％を含有する高珪素鋼板を複数枚積層することで構成された積層鉄心であって、各高珪素鋼板はその表面に熱可塑性樹脂を主成分とする接着型絶縁皮膜を有し、積層されて隣り合う高珪素鋼板どうしが前記接着型絶縁皮膜により接着されていることを特徴とする高珪素鋼板を用いた低騒音の積層鉄心。
【請求項２】　高珪素鋼板の板厚が０．５ｍｍ以下であり、積層されて隣り合う高珪素鋼板間の接着型絶縁皮膜の膜厚が０．３～１０μｍであることを特徴とする請求項１に記載の高珪素鋼板を用いた低騒音の積層鉄心。
【請求項３】　Ｓｉ：４．５～７ｗｔ％を含有する高珪素鋼板をコイル状に巻成形することで構成された巻鉄心であって、高珪素鋼板はその表面に熱可塑性樹脂を主成分とする接着型絶縁皮膜を有し、巻成形されて隣り合う高珪素鋼板部どうしが前記接着型絶縁皮膜により接着されていることを特徴とする高珪素鋼板を用いた低騒音の巻鉄心。
【請求項４】　高珪素鋼板の板厚が０．５ｍｍ以下であり、巻成形されて隣り合う高珪素鋼板部間の接着型絶縁皮膜の膜厚が０．３～１０μｍであることを特徴とする請求項３に記載の高珪素鋼板を用いた低騒音の巻鉄心。
【発明の詳細な説明】
【０００１】
【発明が属する技術分野】本発明は、電気機器のトランスやリアクトルの鉄心、モーターや発電機等の回転機の鉄心、交流磁場を発生させる際に用いられるヨーク等に用いられる積層鉄心及び巻鉄心に関する。
【０００２】
【従来の技術】電気機器の低騒音化のニーズは、近年の電源装置の小型化、高効率化に伴う高周波化によってより一層高まりつつあり、その中でもトランスやリアクトル或いはモータなどの鉄心から発生する騒音の低減化が大きな課題となっている。従来、これらの鉄心材料には珪素鋼板が広く用いられているが、その中でも珪素を６．５ｗｔ％程度含有する高珪素鋼板は軟磁気特性に優れ、磁歪がほぼ零で且つ低鉄損であることから、最近、低騒音用鉄心材料として注目されている。しかしながら、実際には騒音の発生原因は鉄心材料の磁歪振動だけではなく、むしろ鉄心材料間の電磁吸引力による振動が大きな比重を占めており、したがって、このような電磁吸引力による振動対策がなされて初めて低騒音化が達成できる。
【０００３】鉄心材料間の電磁吸引力による振動を抑制するための対策として、鉄心をボルトやバンドで締め付ける方法が知られており、また、他に以下のような提案がなされている。
① 特開平３－１３５００７号公報や特開平４－６１２１１号公報では、鉄心の一部に磁歪の小さい材料を使用することが提案されている。
② 特開平５－２９１０５３号公報では、中心部に方向性珪素鋼板を配置し、その両側に６．５％珪素鋼板のような低磁歪材料を配置した鉄心が提案されている。
③ 特開平５－２５１２４４号公報では、中央部に低磁歪材料を配置し、その内、外周に例えばフェライトのような高周波用磁性材料を配置して高周波鉄損を考慮した低騒音鉄心が提案されている。
【０００４】しかし、これらの提案による鉄心では、騒音の発生をある程度は抑えられるもののその効果は十分でなく、騒音を十分に抑えるためには吸音材や遮音箱でトランスやリアクトルを覆う必要がある。また、特開平５－２５１２４４号公報で提案されている鉄心などは実際の製造自体が困難である。一方、特開平４－３６１５０８号公報では、鉄心材料として高珪素鋼板を用い、鋼板の絶縁皮膜の表面粗さをＲｍａｘで３．５μｍ以上とするとともに、鋼板間に接着機能を兼ねた含浸剤（樹脂系接着剤）を挿入することによって板間に発生する振動騒音を抑えるようにした鉄心が提案されている。
【０００５】
【発明が解決しようとする課題】しかし、この特開平４－３６１５０８号公報のように鋼板間の全体に樹脂系接着剤を含浸させることは実際には極めて困難であり、このため同公報に示されるような低騒音を達成することは難しい。すなわち、同公報では絶縁皮膜の表面粗さが大きいほど騒音が小さくなると述べられ、実施例では表面粗さがＲｍａｘで１２．５μｍのものが示されているが、実際には表面粗さがＲｍａｘで１０～２０μｍ程度では、真空含浸を数時間程度行ったとしても樹脂系接着剤は積層鉄心の端部から１０ｍｍ程度までしか含浸しない。したがって、同公報に示されるような鉄心の実際の製造は極めて困難であり、また、製造できたとしても多大な手間とコストを要することになる。
【０００６】本発明はこのような従来の問題に鑑み、低磁歪材料である高珪素鋼板の特性を最大限に発揮させて騒音が十分に抑えられ、しかも簡単且つ低コストに製造できる積層鉄心及び巻鉄心の提供をその目的とする。
【０００７】
【課題を解決するための手段】このような課題を解決するために、本発明の特徴とする構成は以下の通りである。
(1) Ｓｉ：４．５～７ｗｔ％を含有する高珪素鋼板を複数枚積層することで構成された積層鉄心であって、各高珪素鋼板はその表面に熱可塑性樹脂を主成分とする接着型絶縁皮膜を有し、積層されて隣り合う高珪素鋼板どうしが前記接着型絶縁皮膜により接着されていることを特徴とする高珪素鋼板を用いた低騒音の積層鉄心。
(2) 上記(1)の積層鉄心において、高珪素鋼板の板厚が０．５ｍｍ以下であり、積層されて隣り合う高珪素鋼板間の接着型絶縁皮膜の膜厚が０．３～１０μｍであるこ

とを特徴とする高珪素鋼板を用いた低騒音の積層鉄心。
(3) Ｓｉ：４．５～７ｗｔ％を含有する高珪素鋼板をコイル状に巻成形することで構成された巻鉄心であって、高珪素鋼板はその表面に熱可塑性樹脂を主成分とする接着型絶縁皮膜を有し、巻成形されて隣り合う高珪素鋼板部どうしが前記接着型絶縁皮膜により接着されていることを特徴とする高珪素鋼板を用いた低騒音の巻鉄心。
(4) 上記(3)の巻鉄心において、高珪素鋼板の板厚が０．５ｍｍ以下であり、巻成形されて隣り合う高珪素鋼板部間の接着型絶縁皮膜の膜厚が０．３～１０μｍであることを特徴とする高珪素鋼板を用いた低騒音の巻鉄心。

【０００８】

【発明の実施の形態】本発明の積層鉄心及び巻鉄心は、Ｓｉ：４．５～７％を含有する高珪素鋼板を鉄心材料とするが、この鉄心材料たる高珪素鋼板は表面に接着型絶縁皮膜を有しており、このような接着型絶縁皮膜を有する高珪素鋼板が積層または巻成形され、且つ隣り合う高珪素鋼板どうしが接着型絶縁皮膜により接着されることで鉄心が構成されている。したがって、このような積層鉄心及び巻鉄心は製造が極めて容易であるとともに、鉄心材料の磁歪が小さく且つ鋼板間の電磁吸引力を接着型絶縁皮膜が吸収するため鋼板間の振動が効果的に抑えられ、騒音が極めて小さい。

【０００９】以下に本発明の詳細を説明する。本発明では、鉄心材料としてＳｉ：４．５～７ｗｔ％の高珪素鋼板を用いる。Ｓｉが４．５ｗｔ未満では十分な低磁歪を得ることができない。磁歪はＳｉ含有量が６．６ｗｔ％付近で最小となり、Ｓｉがさらに増加すると再び増大するが、まだ十分に低い値である。しかし、Ｓｉ含有量が７ｗｔ％を超えると鋼板が非常に脆くなるため薄板の製造が不可能となる。

【００１０】また、このような高珪素鋼板としては、Ｃ：１００ｐｐｍ以下、Ｍｎ：５０ｐｐｍ～０．５ｗｔ％を含有させることができる。Ｍｎは、磁歪の小さい高珪素鋼板を製造する上でＳによる脆化を防ぐ作用があり、このため５０ｐｐｍ以上添加することが有効であるが、その添加量が０．５ｗｔ％を超えると鋼の脆化を促進するため好ましくない。また、Ｃの添加量が１００ｐｐｍを超えると加工性が劣化するとともに、鉄損の増大を招くため好ましくない。

【００１１】本発明では、鉄心を構成する高珪素鋼板が表面に接着型絶縁皮膜を有し、積層鉄心または巻鉄心の隣り合う鋼板どうしが上記接着型絶縁皮膜により接着された構成を有する。Ｓｉを６．５ｗｔ％含有する板厚０．３ｍｍの高珪素鋼板を素材とし、鋼板をＥＩ型（ＥＩ－５４）に打抜き加工したものを３０枚積層し、この積層体を鉄心に組み立てるという方法で下記製造例(1)～(4)のＥＩ型積層鉄心を作製し、それらの騒音測定を行った。

【００１２】製造例(1)：鋼板の表面に熱可塑性樹脂からなる接着型絶縁皮膜を施し、この鋼板を打抜き加工したものを積層し、鋼板積層方向に加圧力１０ｋｇ／ｃｍ^{2}で加圧しつつ２４０℃で加熱処理することで積層鋼板間を接着させた積層鉄心
製造例(2)：鋼板の表面に公知の無機有機系絶縁皮膜を施し、この鋼板を打抜き加工したものを積層し、端面の計６箇所を鋼板積層方向で溶接した積層鉄心
製造例(3)：上記製造例(2)の鉄心にH種の絶縁ワニスを含浸させた積層鉄心
製造例(4)：上記製造例(2)の鉄心に接着機能を兼ねた樹脂系接着剤（エポキシ樹脂）を含浸させた積層鉄心
なお、上記製造例(4)の積層鉄心は、無機有機系絶縁皮膜塗付後の鋼板の表面粗さＲｍａｘが１２μｍであり、また、樹脂系接着剤の含浸処理は真空中で３時間行った。

【００１３】これら積層鉄心の騒音（Ａスケール）の測定は、１ｋＨｚ、Ｂ＝１Ｔの条件で励磁した状態で鉄心の正面から１０ｃｍ離れた位置で行った。その結果を表１に示す。同表によれば、接着型絶縁皮膜を有する鋼板を積層させた本発明例の積層鉄心では、公知の無機有機系絶縁皮膜を有する高珪素鋼板を積層させた積層鉄心に比べて騒音が１５ｄＢも減少し、また、公知の無機有機系絶縁皮膜を有する鋼板を積層させ、積層後に絶縁ワニスや樹脂系接着剤を含浸させた積層鉄心に比べても騒音が４～７ｄＢ減少している。

【００１４】また、上記の試験の後、製造例(3)及び(4)の積層鉄心を分解して調べた結果、これらの鉄心では絶縁ワニスや樹脂系接着剤が鉄心中央部まで十分に浸透していないことが判明した。特に、製造例(4)の鉄心では含浸処理を真空中にて３時間行ったにも拘らず、樹脂系接着剤が鉄心中央部まで十分に浸透しておらず、したがって、この方式では含浸剤を鉄心中央部まで完全に浸透させることは極めて困難であることが判った。そして、このように含浸が不十分であることが、上記製造例(3)及び(4)の鉄心の騒音低減効果が劣る原因であると考えられる。

【００１５】次に、本発明の鉄心の接着型絶縁皮膜による効果を確認するため、磁歪の大きい３％Ｓｉ無方向性珪素鋼板を材料として上記製造例(1)～(4)と全く同じ方法でＥＩ型積層鉄心を製造し、同様の騒音測定試験を行った。表２はその結果を示すもので、製造例(1)～(4)の製造条件は素材鋼板が異るだけで表１の製造例(1)～(4)と全く同じである。これによれば、３％珪素鋼板のような磁歪の大きい鉄心材料を使用した場合には、鋼板表面に接着型絶縁皮膜を施し、これを積層させることによる騒音低減効果は極めて小さいことが判る。これは、接着型絶縁皮膜の粘弾性力が板間の振動摩擦を吸収する以上に、磁歪により鋼板自体から発生する振動騒音が大きいためであると考えられる。したがって、磁歪の小さい鉄

心材料を用いることが低騒音を達成する上で非常に重要である。

【００１６】さらに、先に述べた特開平４－３６１５０８号公報の鉄心との作用効果の違いを確認するため、高珪素鋼板の接着型絶縁皮膜の表面粗さＲｍａｘと鉄心の騒音（Ａスケール）との関係を調べた。この試験に用いた積層鉄心は、Ｓｉを６．５ｗｔ％含有する板厚０．３ｍｍの高珪素鋼板の表面に熱可塑性樹脂からなる接着型絶縁皮膜を５μｍの厚さで施し、この鋼板をＥＩ型（ＥＩ－５４）に打抜き加工したものを７０枚積層し、この積層体を鋼板積層方向に加圧力１０ｋｇ／ｃｍ^{2}で加圧しつつ２４０℃で加熱処理することで積層鋼板を接着させた。

【００１７】積層鉄心の騒音（Ａスケール）の測定は、１ｋＨｚ、Ｂ＝１Ｔの条件で励磁した状態で鉄心の正面から１０ｃｍ離れた位置で行った。図１はその結果を示すもので、積層前の接着型絶縁皮膜の表面粗さＲｍａｘと鉄心の騒音には相関は全く見られない。本発明の積層鉄芯及び巻鉄芯では、熱可塑性の接着型絶縁皮膜が鉄心成形時の加圧加熱処理により鋼板表面の凹凸によって生じている鋼板間の空隙を効果的に埋め、これによって層間が強固に固定される。したがって、積層前の接着型絶縁皮膜の表面粗さは、発明の作用効果とは何ら関係しない。

【００１８】次に、図１の試験と同様の積層鉄心を用いて、鉄心に成形された後の鋼板間の接着型絶縁皮膜の膜厚と鉄心の騒音との関係を調べた。この試験では、Ｓｉを６．５ｗｔ％含有する板厚０．３ｍｍの高珪素鋼板（鋼板素地の表面粗さＲｍａｘが７μｍ）の表面に熱可塑性樹脂からなる接着型絶縁皮膜を種々の厚さで施し、これら鋼板を材料として図１の試験と同様の工程で鉄心を作製し、騒音測定に用いた。また、騒音測定は図１の試験と同様の条件で行った。

【００１９】図２はその結果を示すもので、鉄心に成形した鋼板間の接着型絶縁皮膜の膜厚が０．３μｍ以上であれば十分な騒音低減効果が得られている。しかし、膜厚が過度に大きくなると鉄心の占積率を下げるとともに、皮膜の凝集剥離や発粉などの問題を生じるため、膜厚は１０μｍ以下とすることが望ましい。なお、鋼板の板厚の騒音に対する影響も調査したが、板厚が０．５ｍｍ以下の範囲では略同等の効果が得られることが判った。

【００２０】また、鋼板素地の表面粗さが接着型絶縁皮膜の性質に影響することで鉄心の騒音発生に影響を及ぼす可能性を考慮し、鋼板素地の表面粗さ及び接着型絶縁皮膜の膜厚（鉄心に成形した後の膜厚）と鉄心の騒音発生との関係を調べた。この試験では、種々の表面粗さＲｍａｘを有する高珪素鋼板（Ｓｉ含有量：６．５ｗｔ％、板厚０．３ｍｍ）の表面に熱可塑性樹脂からなる接着型絶縁皮膜を種々の厚さで施し、これら鋼板を材料として図１の試験と同様の工程で鉄心を作成し、騒音測定に用いた。また、騒音測定は図１の試験と同様の条件で行った。

【００２１】図３はその結果を示すもので、鋼板の表面粗さＲｍａｘは騒音発生にはあまり大きな影響を与えないことが判る。すなわち、鋼板の表面粗さが比較的小さい場合は接着型絶縁皮膜が薄くても十分な騒音低減効果が得られ、また、鋼板の表面粗さが比較的大きい場合にはその粗さに応じて皮膜の厚みを大きくすればよく、したがって、実質的に鋼板の表面粗さに拘りなく接着型絶縁皮膜による騒音低減効果が得られることが判る。

【００２２】接着型絶縁皮膜は、鉄心とした場合の発熱を考慮して１４０℃程度で所定の接着強度を有し、且つ必要な絶縁抵抗を有する熱可塑性樹脂を主成分とする皮膜である。この熱可塑性樹脂としては、例えば、ウレタン樹脂、アルキッド樹脂、フェノール樹脂、エポキシ樹脂、メラニン樹脂、ポリウレタン樹脂、アクリル樹脂、酢酸ビニル樹脂、珪素樹脂、ポリイミド樹脂の１種または２種以上を用いることができ、また、耐熱性が要求される場合は、上記樹脂中に酸化物微粒子等の無機微粒子を添加してもよい。本発明が対象とする鉄心は、打抜き、放電加工、レーザー加工、エッチング等の加工によって切り出された鋼板を重ねた積層鉄心、カットコアやトロイダルのような巻鉄心であり、また、鉄心の大きさは問わない。

【００２３】本発明の積層鉄心を製造するには、Ｓｉ：４．５～７ｗｔ％を含有する高珪素鋼板の表面に熱可塑性樹脂を主成分とする接着型絶縁皮膜を塗布･乾燥させて施し、この高珪素鋼板を所定の形状に切り出したものを複数枚積層させる。そして、その積層体を鋼板積層方向で加圧しつつ、接着型絶縁皮膜の熱可塑性樹脂が軟化する温度に加熱処理することで、積層されて隣り合う高珪素鋼板どうしを接着型絶縁皮膜により接着する。

【００２４】また、巻鉄心を製造するには、上記のように接着型絶縁皮膜を施した高珪素鋼板をコイル状に巻成形し、この成形体を加熱処理する。巻鉄心の場合には、鋼板をコイル状に巻成形した際の張力により鋼板の積層方向にある程度の加圧力が加わっているため、加熱処理の際の外部からの加圧力の付与は必要ない場合もあり、したがって、鋼板積層方向での加圧力の付与は必要に応じて行われる。

【００２５】また、鉄心を成形した後に巻鉄心の形状固定や磁気特性改善を目的として歪取り焼鈍を行うことができ、この歪取り焼鈍により磁気特性が改善され、これに伴って騒音低減効果も若干向上する。この歪取り焼鈍は７００～８５０℃で行うことが好ましく、歪取り焼鈍を行う場合は接着型絶縁皮膜には耐熱性のある熱可塑性樹脂を用いることが好ましい。なお、接着型絶縁皮膜は歪取り焼鈍により若干劣化するが、層間に固定されているため騒音低減効果はあまり損なわれない。また、本発

明の積層鉄心及び巻鉄芯は、層間全体が接着型絶縁皮膜により確実に固定され、絶縁ワニスや樹脂系接着剤を含浸させる方式のようにワニスや接着剤が鉄心の内部が行き渡らないという欠点がなく、このためＥＩコアやカットコアなど磁気ギャップを有する鉄心についても鋼板の層間に磁束が横切るためその効果は十分に大きい。

【００２６】

【表１】

表１

区　分	騒音（dBA）
製造例(1)	31
製造例(2)	46
製造例(3)	38
製造例(4)	35

【００２７】

【表２】

表２

区　分	騒音（dBA）
製造例(1)	62
製造例(2)	68
製造例(3)	64
製造例(4)	63

【００２８】

【実施例】〔実施例１〕Ｓｉ含有量がそれぞれ３．０ｗｔ％、５．９ｗｔ％、６．５ｗｔ％の珪素鋼板（板厚０．３ｍｍ）を素材として、下記製造例(1)～(3)のＥＩ積層鉄心を作製した。

製造例(1)：熱可塑性樹脂（アクリル樹脂）からなる接着型絶縁皮膜を塗布、乾燥させた上記各鋼板を所定の形状（ＥＩ－６５）に打ち抜き、これを積層して、加熱温度２００℃、加圧力１５ｋｇ／ｃｍ^{2}で加圧加熱処理することで接着型絶縁皮膜により積層鋼板間を接着し、鉄心に成形した積層鉄心

製造例(2)：公知の無機有機系絶縁皮膜を塗布、乾燥させた上記各鋼板を所定の形状（ＥＩ－６５）に打ち抜き、これを積層して締め付け及び成形した積層鉄心

製造例(3)：公知の無機有機系絶縁皮膜を塗布、乾燥させた上記各鋼板を所定の形状（ＥＩ－６５）に打ち抜き、これを積層して締め付け及び成形した後、真空中にて樹脂系接着剤を含浸（含浸時間：３時間）させた積層鉄心

【００２９】このようにして得られた積層鉄心を１ｋＨｚ、Ｂ＝１Ｔの条件で励磁し、騒音計により鉄心から１０ｃｍ離れた位置でＡスケールで騒音を測定した。その結果を表３に示す。これによれば、接着型絶縁皮膜を有する高珪素鋼板（Ｓｉ：６．５ｗｔ％、５．９ｗｔ％）を積層させた本発明例の積層鉄心では、公知の無機有機系絶縁皮膜を有する高珪素鋼板を積層させた積層鉄心に比べて騒音が１５～１６ｄＢも減少し、また、公知の無機有機系絶縁皮膜を有する高珪素鋼板を積層させた後、樹脂系接着剤を含浸させた積層鉄心に比べても騒音が４～５ｄＢも減少している。一方、３％珪素鋼板を用いた積層鉄心はいずれも全体の騒音レベルが高く、また、本発明のように接着型絶縁皮膜を有する鋼板を積層させることによる効果も小さい。

【００３０】〔実施例２〕Ｓｉ含有量がそれぞれ３．５ｗｔ％、５．７ｗｔ％、６．６ｗｔ％の珪素鋼板（板厚０．１ｍｍ）を素材として、下記製造例(1)～(4)のカットコア（ＣＳ２００）を作製した。

製造例(1)：無機系接着剤からなる接着型絶縁皮膜を塗付、乾燥させた上記各鋼板を巻成形し、これを３５０℃で加熱処理することで接着型絶縁皮膜により積層鋼板間を接着したカットコア

製造例(2)：公知の無機有機系絶縁皮膜を塗布、乾燥させた上記各鋼板を巻成形し、これに８００℃、２時間の歪取り焼鈍を施した後、絶縁ワニスを含浸させたカットコア

製造例(3)：公知の無機有機系絶縁皮膜を塗布、乾燥させた上記各鋼板を巻成形し、これに８００℃、２時間の歪取り焼鈍を施した後、真空中にて樹脂系接着剤を含浸（含浸時間：３時間）させたカットコア

製造例(4)：無機系接着剤からなる接着型絶縁皮膜を塗付、乾燥させた上記各鋼板を巻成形し、これを２５０℃で加熱処理をすることで接着型絶縁皮膜により積層鋼板間を接着し、これに８００℃で歪取り焼鈍を施したカットコア

【００３１】このようにして得られた巻鉄心（カットコア）を２ｋＨｚ、Ｂ＝０．５Ｔの条件で励磁し、騒音計により鉄心から１０ｃｍ離れた位置でＡスケールで騒音を測定した。その結果を表４に示す。これによれば、接着型絶縁皮膜を有する高珪素鋼板（Ｓｉ：６．６ｗｔ％、５．７ｗｔ％）を巻成形した本発明例の巻鉄心では、公知の無機有機系絶縁皮膜を有する高珪素鋼板を積層させた後、絶縁ワニスを含浸させた巻鉄心に比べて５～６ｄＢ程度騒音が減少し、また、同じく樹脂系接着剤を含浸させた巻鉄心に比べても３ｄＢ程度騒音が減少している。一方、３．５％珪素鋼板を用いた巻鉄心はいずれも全体の騒音レベルが高く、また、本発明のように接着型絶縁皮膜を有する鋼板を巻成形することによる効果も小さい。

【００３２】〔実施例３〕Ｓｉ含有量がそれぞれ０．５ｗｔ％、５．０ｗｔ％、６．５ｗｔ％の珪素鋼板（板厚０．３ｍｍ）を素材として、下記製造例(1)～(3)のステータを作製した。

製造例(1)：熱可塑性樹脂（アクリル樹脂）からなる接着型絶縁皮膜を塗布、乾燥させた上記各鋼板を所定の形状に打ち抜き、これを積層して、加熱温度２８０℃、加圧力２０ｋｇ／ｃｍ^{2}で加熱加圧処理することで接着型絶縁皮膜により積層鋼板間を接着したステータ

製造例(2)：公知の無機有機系絶縁皮膜を塗布、乾燥させた上記各鋼板を所定の形状に打ち抜き、これを積層してかしめ成形したステータ

製造例(3)：公知の無機有機系絶縁皮膜を塗布、乾燥させた上記各鋼板を所定の形状に打ち抜き、これを積層してかしめ成形した後、真空中にて樹脂系接着剤を含浸（含浸時間：３時間）させたステータ

【００３３】このようにして得られた積層鉄心（ステータ）を用いて作製した高速誘導電動機を無負荷、３００００ｒｐｍで回転させ、モータから１０ｃｍ離れたところで騒音計によりＡスケールで騒音測定した。その結果を表５に示す。これによれば、接着型絶縁皮膜を有する高珪素鋼板（Ｓｉ：６．５ｗｔ％、５．０ｗｔ％）を積層させた本発明例の積層鉄心では、公知の無機有機系絶縁皮膜を有する高珪素鋼板を積層させた積層鉄心に比べて騒音が１２～１３ｄＢも減少し、また、公知の無機有機系絶縁皮膜を有する高珪素鋼板を積層させた後、樹脂系接着剤を含浸させた積層鉄心に比べても騒音が２～３ｄＢ減少している。一方、０．５％珪素鋼板を用いた積層鉄心はいずれも全体の騒音レベルが高く、また、本発明のように接着型絶縁皮膜を有する鋼板を積層させることによる効果も小さい。

【００３４】

【表３】

表 3

区　分	騒　音（dBA）		
	6.5wt%	5.9wt%	3.0wt%
製造例(1)	32	41	64
製造例(2)	48	56	71
製造例(3)	36	46	66

（注）下線部が本発明例

【００３５】

【表４】

表 4

区　分	騒　音（dBA）		
	6.6wt%	5.7wt%	3.5wt%
製造例(1)	40	50	67
製造例(2)	45	56	70
製造例(3)	43	53	68
製造例(4)	41	51	68

（注）下線部が本発明例

【００３６】

【表５】

表 5

区　分	騒　音（dBA）		
	6.5wt%	5.0wt%	0.5wt%
製造例(1)	49	55	69
製造例(2)	61	68	77
製造例(3)	52	57	70

（注）下線部が本発明例

【００３７】

【発明の効果】以上述べた本発明の積層鉄心及び巻鉄心によれば、製造が極めて容易であるとともに、鉄心材料の磁歪が小さく且つ鋼板間の電磁吸引力を接着型絶縁皮

膜が吸収するため鋼板間の振動が効果的に抑えられ、従来の積層鉄心及び巻鉄心に比べて騒音をより低減化することができる。

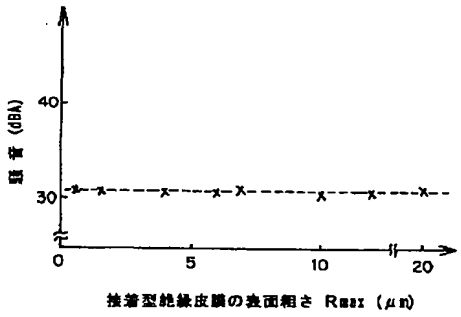
【図面の簡単な説明】

【図１】鉄心に成形する前の接着型絶縁皮膜の表面粗さＲｍａｘと鉄心の騒音との関係を示すグラフ

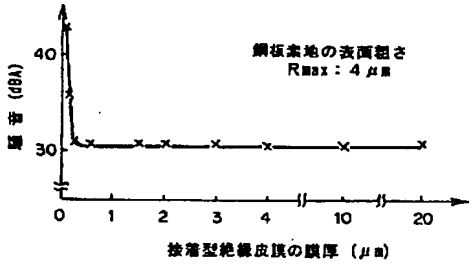
【図２】鉄心に成形した後の鋼板間の接着型絶縁皮膜の膜厚と鉄心の騒音との関係を示すグラフ

【図３】接着型絶縁皮膜が設けられる鋼板素地の表面粗さＲｍａｘ及び鉄心に成形した後の鋼板間の接着型絶縁皮膜の膜厚と鉄心の騒音との関係を示すグラフ

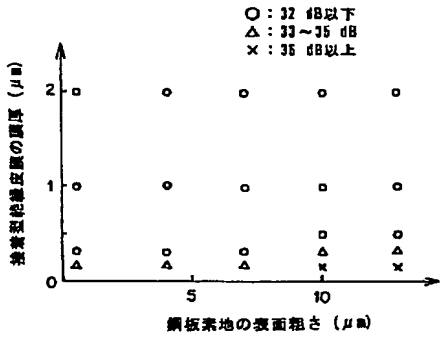
【図１】



【図２】



【図３】



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